# Mschool

## Where Everything is Learned Through Music


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# A Vision

An imaginary extract from the local newspaper of small town in a distant region of a distant country dated 2010.

This year's public performance by the MSchool students was declared to be a great success by everyone except the Visitor from the International Organization. The piece that received the longest applause was *Three Generations* -- a performance created by a group of 25 students of different ages with the cooperation of members of the community as well as several teachers. The children had interviewed grandparents and parents and contemporaries about the music and dance they had liked in their youth as well as about their attitudes on a range of controversial issues such as hair style, dating habits, social manners and the best choices of careers. What they learned informed a series of short sketches (created by different groups of students) each of which plays out a family dispute about one of the issues. The most striking feature of the sketches was music composed by the students using composition software to combine into a more or less integrated piece melodies to match the tastes and periods and actions of the characters in the sketch. The sketches had very different formats, most using dance, mime and acting to varying extents and in varying combinations. But the most unusual was a hi-tech form of puppet theater: "no strings" … the puppets, which showed a striking melding of hi-tech functionality and warmly appealing aesthetics, were designed and built by the students who controlled them remotely from computers via wireless links as they told a story in mime danced to original music.

At the party after the show the Visitor congratulated the principal of the school on the talents of her wonderful students. Although he had thoroughly enjoyed the show and been surprised by its high standards he was concerned about the children spending their time on things like this, enjoyable as they might be, and using skills that obviously needed much time to acquire, when there was such a great need for them to be learning math and science and how to write business letters. The principal assured him that Mschool students excelled in all those areas. "But how can that be?" – he asked -- "Schools are already overloaded trying to teach the basics. How can they give time to music and theater and still do their job?"

Instead of retelling the underlying ideas for the umpteenth time she gave him the Founding Papers – the original proposal to create the school.

## The Idea in a Nutshell

The immediate concrete goal of the project is to design and implement a school ("Mschool") based on principles whose briefest description is "Everything will be learned through music." *Music* is taken in a broad sense that could perhaps be better described as "the music arts." Other goals include:

- Providing a model with the potential of changing thinking about what is educationally feasible in both developing and developed countries
- Providing material that could be used both by schools wishing to restructure themselves in a fundamental way and by those wishing to make a partial implementation of the methodologies used in Mschool
- Contributing to closing the cultural gap separating "the sciences" (taken here as shorthand for science, mathematics, technology etc) from "the arts" (taken here as shorthand to include humanistic and artistic studies.)[1]
- Developing a perspective on the roles of digital technologies in learning

It may appear paradoxical to many educators that we propose to solve the problem of overload in schools by covering more ground at a deeper level. The strategy is based on long research that confirms our belief in the Harel Principle: "Teaching more can be easier than teaching less." If knowing X makes Y more meaningful, learning X can reduce the time needed to learn Y. Of course nothing would be gained if X is not worth learning in itself or if the time needed to learn it is greater than what is saved on Y. Many years of research allow us to develop ways of developing synergies between learning in the arts and in the sciences in such a way that the two can be learned together in any given time to a greater depth than either gets in traditional schools.

The educational theory behind our work is based on the work of many theorists such as Dewey, Piaget, Montessori, Vygotsky, Frenet, Freire as well as some contemporaries such as Howard Gardner who have clearly shown that learning becomes far more effective when embedded in creative and congenial activity. *These ideas have not taken deep root in educational practice because of difficulties in finding creative activities that connect closely enough with areas in the sciences and especially with mathematic*s. Our major contributions over the past few decades has been developing ideas and methodologies that allow us, in the new context of digital technology, to recognize the arts as a fertile source of the hoped-for creative activities. Even a superficial observation of children shows that drawing, singing, dancing, acting, fantasizing and other precursors of the arts are, for most children, the primary expressions of active creativity. Closer observation reveals that early development of geometric and numerical skills and "thinking skills" takes place largely in the course of such activities. Our key idea is to use technology to continue this connection in ways that were not possible in the days of "paper-and-pencil"schools. For example: students, even young children, who become fluent enough in using the computer as an instrument of artistic creation are able and motivated to use mathematics to obtain more effective results. Thus mathematics becomes meaningful to them as a means to achieve something that comes from their own desires. As a result they learn it faster and more deeply.

In addition to the traditional educational theories modern work on neurology is providing far deeper insights into the fact (which was always suspected) that musical and physical activities play a special role in learning.

The following pages will give examples of numerous ways in which technology allows creative activities in the musical arts to enrich many if not all areas of learning. We begin with a fuller discussion of four principal ideas: active-creative learning is the most effective learning; the arts are the area where children can best give reign to their creative instincts;

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[1] Since our idea is to bring the two together we need not work hard at finding a precise line of separation,

motion and music have a special place in the development of mind; digital technology provides the context and the instruments to make the connections to realize these potentials. Many of our examples exemplifying these ideas can be fruitfully applied piecemeal within a traditional school structure. But what is most distinctive is opening the possibility of redesigning school in ways that will help set new sights for the use of language such as "re-inventing school" or "twentieth century learning."
We insist throughout on seeing the relationship between sciences and arts as a two-way street. We are vehemently opposed to any idea that the arts should be included in education *primarily* for what they contribute to other learning, although this is very substantial. We are driven in our work as much by wanting to counter the widespread tendency to treat the arts as less important in education and in life as we are by wanting to improve learning of mathematics, science and grammar.

All this will not be achieved by simply putting more computers or more pianos or more music teachers in otherwise unchanged schools. We have devoted many years to developing methodologies of teaching learning and, indeed, of thinking that lead eventually to a deeply new concept of what schools is like – of how it is structured and of how its many participants relate to one another and to the surrounding communities. We offer the design of Mschool not as a panacea to be copied by everyone everywhere but as an example that we hope will inspire others to explore directions beyond anything we have imagined.

Time Course

In the following time map the first four years are a commitment; the following two a hope; the remainder a possibility.

| Years Ahead | What we expect to do/see |
|---|---|
| 1 | Develop plan; implement some software for testing and demo |
| 2 + 3 | Implement materials for partial experiments in schools near us in USA. Recruit and train collaborators for work in Venezuela |
| 4+5 | Launch pilot school in Venezuela. Document operation.<br>Make materials available for partial implementation<br>Make broadcast quality video about project<br>Small group of intellectuals, educators and researchers forms to take initiative in extending the idea |
| 5-8 | News of pilot will lead to many schools adopting "partial use" of materials and creation of a few implementations of the pilot] |
| 7+ | Successes lead to larger movement for new Education in Latin America |
| 8-10 | By this time the ideas have been developed and the cost of technology + connectivity fallen to a level where massive implementation of New Education becomes feasible.<br>Extension of concept to other areas besides music. |
| 10 + | The current concept of giving all children in the world a minimal "primary education" is replaced by the realistic prospect of giving all children the opportunity to the standards now set in the most educationally developed countries. |
| One Day | Thinking about Learning in a holistic way has undergone a development analogous to the emergence of the concept of "environmentalism" – but more successfully. The unit of thinking is now "the global learning environment." |

Notes on Technology

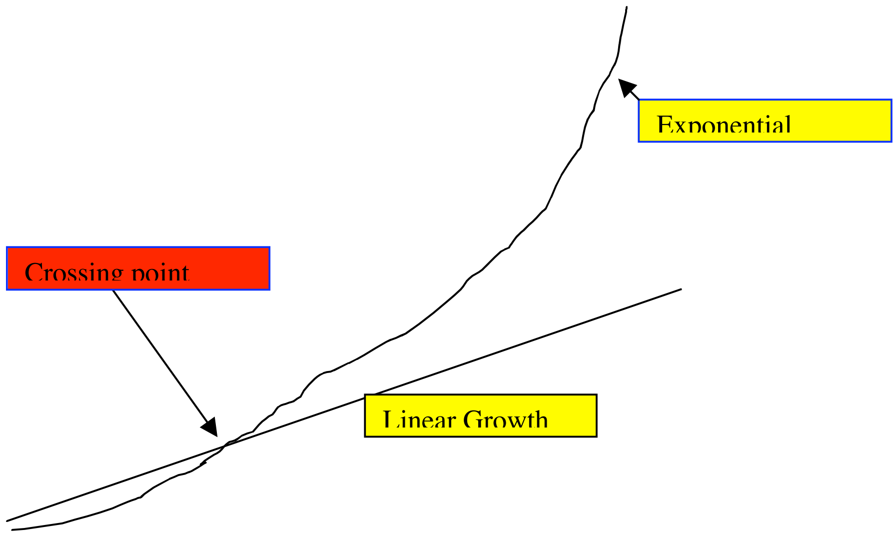
1. Patterns of Growth in the Social Appropriation of Technologies.

The core of the paper will be devoted to the educational ideas underlying this plan but we request readers to have the patience to peruse a first section about how we see the process of social appropriation of new technologies and the kinds of general strategy we use to facilitate appropriation and overcome resistances

This section develops the following ideas:

1. The natural first use of a new technology is to improve the doing of something that is already being done. In some cases history shows that the first idea is the ultimate one. The plough, for example, might become better and better with time but in the end is still used for turning the soil. In other cases a technology eventually gives rise to uses that go far beyond anything the original inventors could imagine. Marconi invented "radio" with the idea that it would be useful for ships in distress to call for help. The transformative roles now played by wireless technology emerged slowly over a period of decades. Indeed a century later we may still be only on the threshold of what "wireless" will do to our lives. Although the distinction can never be sharp, the discussion of technology is helped by naming these two developmental patterns. Provisionally we call them linear and exponential.

2. The distinction between two patterns helps us formulate strategies for research and development. Faced with a new technology workers in a field where it might be used have the choice of pursuing its additive or its exponential uses. In the case of information technologies and education the additive uses have proved so valuable in themselves that the major effort has gone into their development. The two prime examples are using computers to automate and to enliven tutorials or drill and practice and using telecommunications for distance learning without trying to introduce fundamental change in the content of what is being learned. We have no doubt that these uses will continue to grow in scale and in quality just as the use of radio to help ships in distress has been strengthened not bypassed by other uses of radio. But at the same time there existed from the beginning a niche for the exploration of exponential directions. The ideas presented here grew out of a long process – some thirty years -- of carefully nurturing ideas which were too far from current practice to have an early impact. But we believe that they are now at the crossing point illustrated by the graph showing the relationship between linear and exponential growth.




Exponential growth has a slower start but eventually far exceeds linear growth

3. In the case of education the acceptance of exponential uses of technologies has been delayed by a number of special factors. While all these factors must be taken seriously in developing strategies for moving into the exponential realm, we distinguish between those we respect as an essential part of the process of change and those that need to be
    a. One of these which we treat with the greatest respect in the design for the school proposed here is a natural caution about anything that resembles "treating children as guinea pigs."
    b. While caution is to be commended it must not be confused with resistances to change with roots such as:
        i. Bureaucracy
        ii. Ignorance

A more complex factor that stems from the failure in the education establishment (including the academic community and the policy-makers in many funding organizations) to admit the concept of exponential change in education. This intellectual blind spot leads to throwing out essentially exponential ideas by conducting experiments based on early forms that lie to the left of the crossing point. The design for a school presented here uses several ideas that have been given a bad name in education circles by this kind of premature ejaculation.

## 2. Roles of Technology in Learning

### From constructivism to constructionism.

Recap: The constructivist thesis asserts that knowledge has to be constructed by the learner – it cannot be transmitted ready-made. The task of the educator is then not to give knowledge but to foster situation in which the learner can do this construction. We have noted examples illustrating the fact that the possibilities for doing this were very limited but can in principle now be greatly expanded using digital technology. To turn principle into practice in ways that will not fall into the limitations of the three "pseudo-solutions" of the previous section we would like to find activities satisfying three conditions:

The activity must be genuinely interesting to children – preferably touching real passion

The activity must offer scope for individual and collective creativity

The activity should have *child- accessible*, *intellectually deep* and *empowering* connections with the areas of knowledge in which one hopes to foster learning – in this part of our discussion, with mathematics

The first two conditions strongly suggest the arts but in a traditional setting connections between the arts and mathematics generally satisfy one or two but very seldom all three of the italicized conditions. For example, counting in dance or music is accessible to children and even empowering but in itself does not lead to connection with deep mathematical ideas. Harmony in music and perspective in painting both spawned and are connected with important themes in mathematics. But the mathematics is not accessible to children and is not empowering. But this is where digital technology shows its strength: *it turns mathematics into a tool to serve artistic purposes.* We make the point by mentioning three ways in which this can happen. More will be come up later.

1. <u>The computer becomes the medium</u>. An artist drawing on paper and a geometer both deal with shapes but don't have much help to offer one another. Especially of the artist is a child, knowing mathematical principles of geometry will not improve (empower) drawing; and there would be few opportunities to bring experience with drawing to bear on a problem in geometry. But the situation is radically different if the artist is creating graphics or animations on a computer screen. Geometrical knowledge can open new horizons of effects to serve artistic creativity. Conversely the experience of doing this can support understanding issues in geometry.

   Similar connections with harmony and counting are no less important but will be more easily explained when we have developed some other ideas and examples

2. <u>The technology serves as a tool-set</u>. A later section will describe how dance can be enhanced by using sensor technologies to allow a performer to control features of the environment: for example the expression of anger can be enhanced by adding direct control light effects to the gesture and sound traditionally used to express it.

3. <u>The technology serves as a material</u>. Many elementary school students find it intriguing to construct their own musical instruments and when they do so ides related to harmony and the mathematics of scales become useful and in this concrete context quite accessible.

## SOME COMPARISONS WITH OTHER EDUCATIONAL ENDEAVORS

As a step towards explaining our theoretical framework we situate out Mschool design with respect to some exemplary examples of educational endeavors that share features with it but are fundamentally different.

1. Endeavors specifically involving the arts and the education of children.

   1.1. The Vaganova School of ballet in St Petersburg, Russia, has been a prestigious model for over two centuries of a full time school designed exclusively for students who have already developed by age 9 a level of talent and of dedication that will make most of them follow careers in dance. The students receive a full education but what is special about the school is the unexcelled quality of teaching in areas (such as music theory) closely related to this special interest. In other areas such as physics or mathematics a teacher might emphasize aspects related to the special interest but the presentation of the core of these subjects is quite traditional and somewhat reduced in comparison with what a student might learn at a regular school and certainly by comparison with what would be learned at a school specializing in these subjects.

   Our school is not designed primarily for students who will follow careers related to music. Its intention is to enhance "other subjects" (such as mathematics, science, grammar, history etc) by their linkage with the creative arts and at the same time to enhance development in artistic dimensions by linking them with the other subjects. Thus, although the school will provide excellent learning opportunities for students who have a special interest in music, it will serve equally well *every* student who is responsive to *any* aspect of the musical arts -- which we believe means *all* students. Indeed we believe, and accept as the criterion by which our work should be judged, that this school would provide a better foundation in subjects such as science and mathematics than schools that specialize more narrowly on these areas.

   1.2 The MOMA program in visual learning provides another interesting point of comparison. We share with this project the general idea that work in the area of arts can contribute to the development of thinking skills to be used in all intellectual areas. Indeed we will borrow some specific ideas from it. But we go much further in the direction that it has set. The VE program can be classified as *enrichment* rather than *transformation* of the traditional school subjects in that it consists of inserting an hour or two a week in an otherwise traditional school program whereas our school will replace the traditional school program by an entirely new one.

   1.3 The "Learning Through Music" program of the New England Conservatory combines features of 1.1 and 1.2 and is closer to our program in some essential respects which we explain after mentioning three differences:

   - The NEC program makes only incidental use of of modern digital technologies. Our program recognizes its potential to transform learning in ways that were not previously possible
   - Consequently the content of traditional school subjects in the NEC schools is certainly enhanced by what their literature calls being "intertwined with music" but is not deeply changed. Even the learning of music is, relatively speaking, an enhanced form of traditional methods rather than a new approach.The NEC program is

based on Howard Gardner's thinking which in our design figures as one, and not the most important, of several strands of educational theory.

Among the positive features which we share are:

- Giving the arts far greater value in the eyes of children as well as of teachers
- Giving children experiences of true quality (as opposed to the "age-appropriate" bowdlerized stuff that fills the school textbooks.)
- Recognizing that "thinking about the arts" is "thinking." The arts provide a superior medium for developing thinking skills of universal application

In brief: we fully agree with the new elements that the NEC project wishes to introduce into school; our differences lie in our recognition of the possibility to go much further towards developing a new concept of schooling sand a new relationship between the arts and the sciences in learning, with a greater emphasis on individual creativity and design and the development of new ways of thinking through music.

2. <u>The "Magnet School" Concept</u>

The jargon of school reform might refer to our proposed idea as a "magnet school" emphasizing its similarities with a concept that has been widely applied in the past few decades. Many so-called schools give themselves a specific character by adopting a theme which could in fact be though it is more often something like "technology" or "science" which is thought to be pragmatically relevant to the needs of school graduates and attractive to parents in situations where school choice is allowed.

Two kinds of comparison will help define our position:

- Our school could certainly serve as a magnet school. But note that it could equally well be described as a "technology magnet" or a "math/science magnet" as a "music magnet." Our uses of techgnology and the technological sophistication our students will acqure far exceed what is generally offered in "technology magnets"!
- What we said about the "Learning Through Music" project of the New England Conservatory applies with greater force to this comparison. Perhaps it would not be unbfair to summarize this by a diufference in intention: ours is to develop quite new ways of teaching everything including the sciences while the magnet school movement genrally aims at bringing "best practices" (i.e.the est of what is already beinjg done) to larger populations of students.

## Notes on Educational Philosophy

### "A Child is a Lamp to be Lighted … Not A Vessel to be Filled"

This aphorism written at the door of the Lamplighter School in Dallas expresses an intellectual theme that runs through the history of twentieth century education reform. Many reformers (often called "progressive educators") have criticized school for what they disparagingly call "pouring knowledge into the heads of passive pupils." They argue that learning would be better in what they call "constructivist learning environments" designed to stimulate and guide children in the active and creative pursuit of knowledge. *We believe that these critics of the traditional school are right*[2]. But so are the critics of the critics who argue that no truly compelling such environment has been produced: in practice all the models that have been offered either depend on special conditions that cannot be replicated on a mass scale or achieve replicability by diluting the content of what is learned. Through the twentieth century the debate went back and forth in a repetitive cycle: new variations on the progressive theme were proposed and their failure to take hold fed new upsurges of support for "back to basics."

Of course interpretations of this history differ[3]. Traditionalists see it as simply proving that the progressives are wrong. On the hand progressives easily find excuses that ultimately reduce to blaming one or the other of the many forms of conservatism that undermine any attempted change in the working of the education system. It is said, for example, that parents want their children to learn as they learned, teachers want to teach as they were taught and funders of research want to hedge their bets by backing projects that do not deviate far from well known territory. However the element of truth in each of these arguments obscures a more fundamental factor.

The simplest statement of the explanation that inspires the thinking behind this paper is that progressive education was an idea whose time had not yet come but now has. We develop our argument by presenting the design of a school to show how modern technology makes possible a level of creative, active learning beyond what any of the great thinkers about education in the past could have imagined. Thus in our historical period it becomes possible for the first time to contemplate a real implementation of the idea of progressive education and doing so leads quickly to carrying these ideas further than their originators could do. We find especially satisfying the fact that this extension allows us to integrate the ideas of thinkers such as Dewey or Piaget or Vygotksy or Montessori or Frenet or Freire who are often seen, and in some cases saw themselves, as theoretical adversaries.

Our explanation of the sharp differences that have fragmented the progressive education movement into divisive schools of thought is this:

In the olden days (say up to the last quarter of the twentieth century) the possibilities of active learning were so severely limited that an education reformer had to concentrate on one corner or another of the "learning environment" in order to have any hope of doing anything significant either theoretically or

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[2] This must be read as "they are right in principle." Later in the paper we shall look more closely at the multiple interpretations that can be placed on the essentially metaphorical formulations of this issue that pervade even the most academic discussions.

[3] For a good typical sociological discussion see: Tyack and Cuban: *Tinkering Towards Utopia.* For a sample of the sharpness of debates point Google to "Math Wars." For an elaboration of the interpretation presented in this paper see: Papert: ………

practically. Today the affordances are so great that we can allow ourselves to take a holistic view and seek solutions that will satisfy all of the various aspects of learning that each of these individual thinkers selected as *the* key issue. Of course there is stillroom for differences in theoretical explanations of why some kinds of learning work better than others. But we no longer have to think about whether the school we design is Piagetian or Vygotskian or Montessorian or whatever: we believe that the originators of all forms of progressive education educators would find it to their liking even if they based their approval on different theoretical arguments.[4]

The relationships with these various schools of thought will be brought out in the course of discussing concretely details of our design in later sections of the paper. The present overview will offer a narrowly focused discussion of one aspect in order to bring out as clearly as possible a central driving thought. Nuances will come later. Thus, for the moment we narrow discussion to teaching and learning in mathematics, which we see as an extreme case of the issues that come up in all subjects: it is in the math class where the criticism of "passivity" is most pointed; it is the area in which the obstacles to giving children truly active and creative work are most formidable; it is certainly the area where the new offering of digital technologies are most far-reaching. It is also the field in which it has been especially easy to get away with superficial pseudo-solutions to the problem of making work in the math class more active and creative.

Looking at three kinds of pseudo-solution will provide a starting point for delimiting more precisely the problem the progressive educators have been trying to solve and opening the way to deeper kinds of solution. We emphasize in advance that we are entirely in accord with the *intentions* of these "pseudo-solutions." What makes them "pseudo" is that they do not go far enough to solve the problem; unfortunately they do go far enough to give the progressive approach a bad name.[5]

> Pseudo-solution #1: *Making math "relevant"*. Progressive educators observe that in the math class students often find it hard to see why they should be doing the work they are given. They believe that students would approach it in a better spirit if they felt that it was more "relevant." Undoubtedly true, but this leaves open the question: relevant to what? The writers of many textbooks seem to think manipulations on numbers become more "relevant" when they are connected with "real-life" situations such as deciding whether $1.10 for 250 grams is a better buy that $1.90 for a pound. But most students don't find this kind of thing personally relevant; perhaps for the poor reason that they think such things are for adults or perhaps for the good reason that they know that in this age of electronic devices even adults never do such comparison-shopping. We cannot blame the writers of textbooks for their choice of poor ways to show relevance. It is a fact beyond their control that there are few deep connections between the kind of mathematics in the curriculum and the lives of the children. At least this was true at the time the style of these books was developed. But imagine now a child who is passionately interested in music and can use mathematics to make a

[4] The design will also bridge over the rift that has become especially sharp in recent years between the constructivist view with origins in Piaget's thinking and the more genetically-biologically oriented views that stem from Chomksy and the school of "evolutionary psychology."

[5] Rather like taking a medicine in a dose that is large enough to produce bad side effects but not large enough to produce a cure.

computer do musical things. Or a child who is passionate about computer games and is offered the possibility of using mathematics to master a game or to design and implement his own. Or children making economic or ecological simulations to help their community's plans for development. This is a different – and more relevant -- kind of relevance.

Pseudo-solution #2: *Making math "active"*. Instead of sitting on benches in a classroom the students are given a project such as measuring the schoolyard or investigating the distribution of pets in the homes of their classmates. Undoubtedly it is better to get exercise but again but as active learning of mathematics this is limited in two ways. The first does not require any subtle thinking: it is easy to see that the mathematics involved in this kind of project may be useful but is very limited. Measuring a field might reinforce ideas about units of measurement and simple multiplication. But these are neither the parts of school mathematical that give the most trouble to students and teachers nor source of deep connections with big mathematical ideas. The second limitation requires some deeper thinking, which we will be taking a little further in each section of this paper. For the moment we only remind readers that there is active and there is active. The "active" of a pianist deeply absorbed in his expressive playing is not the same kind of state as the "active" of a hyperactive child running mindlessly around the room. Before we can begin to talk sensibly about "active" learning we need to build up a way to classify different ways of being active. As we do so we shall see how the technology allows us to create conditions for far more active – more deeply engaged – kinds of activity.

Our discussion of the next "pseudo-solution" makes a start at putting more structure into the notion of active by taking a closer look at one kind that has played a significant part in proposals for progressive education.

Pseudo-solution #3. *The "discovery method" of teaching*. The most extreme proponents of this pedagogic approach will refuse to tell children anything they could discover for themselves. In their view the job of the teacher is not to provide ready-made knowledge (such as "the way to add fractions is ……") but to create situations in which children could invent their own methods. Once more we postpone to later sections a more subtle discussion of this idea, including an examination the argument (in our view half true but misleading) that the "discovery strategy" follows from the constructivist philosophy espoused most forcibly by Jean Piaget. Here we focus on a non-standard explanation of the sometimes real and sometimes merely apparent reported successes. Simply stated: when the method works it does because the activity of "trying to discover" is a more effective catalyst of engagement than the repetitive exercises offered in typical textbooks. If the activity has a unique quality, this is not because it conforms to the epistemological dogma that knowledge must be discovered in order to be learned but because it is relatively very engaging compared with the small number of things to do with such knowledge available in the olden days to teachers and children. Our goal is to create learning environments in which "discovery" becomes just one out of a profusion of activities that that lead to deep engagement with mathematical knowledge. The trick is to create environments in which the knowledge children are expected to acquire can be used in diverse and interesting ways in the here and now rather than being banked away (to use Paulo Freire's metaphor) in case it will one day be useful.

The environments we envisage will not neglect “discovery.” Quite the contrary they will elevate it: but what will be discovered is not a few dozen formal rules but the unlimited number of ways in which any piece of mathematical knowledge can be used.

**CONTENT Part 1**
**EMPHASIS ON MATHEMATICS**

Turtle Geometry illustrates concretely several features we try to bring into all learning:

1. The learner is able to become familiar with its methods and ideas by playing with them. As soon as a few elements are mastered it is already possible to use them to do something personal that feels creative and generates excitement.
2. The work is sharable with other learners.
3. Problems can be solved by connecting with familiar pools of knowledge for example the very familiar *activity* of finding one's way or walking in a pattern.
4. The anthropomorphic nature of the turtle establishes a bodily connection
5. The quasi-linguistic nature of the formalism draws on familiarity with language.
6. The relationship with bodily movements and with natural language possibly connects this learning with deeply rooted innate brain mechanisms.
7. There is a strong connection with other areas of application
8. There is a strong connection with powerful ideas.

Connection with dance.

A step in this direction is made by introducing dynamics into work with screen turtles and with floor turtles. We have seen children become deeply engaged in choreographing in both these contexts, that is to say composing movements and sequences of movements whose interest, like different styles of ballet, could lie in the pure abstract movement or in representing the unfolding of a story or, most usually, a combination of both where one or the other might be closer to the center of attention of the artist.

This extension creates a need for new mathematical ideas or for a more refined use of old ones. When things move they have a speed which must be represented by a mathematical form such as a number or a line length. When the things interact small differences in speed can be critical and the use of decimal notation to be able to find a number of just the right size becomes a valuable tool.

Dance allows a completion of a circle of ideas: human movement was used to build turtle geometry which was used to learn a dynamic mathematics to control the movement of artificial entities on screens or on the floor and now this c a be used to choreograph human dancing.

Rhythm and time.

The connection with turtle geometry puts an emphasis on the spatial side of dance. Geometry is the mathematics of space. But dance, like all musical forms, involves time as well as space and the computer allows us to make connections between mathematics and the control of time.

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  1 2 3 4 5 6 7 8 9 10 11 12 . . . .
  1 2 3 4 5 6 7 8 9 10 11 12 . . . .
. | | | . | . | | | . |
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A very simple example of the connection is the "aha"kind of expression we have heard from children who suddenly realize that the method they have been using to program complex rhythms is exactly the same as the boring and rather mysterious processes in classes on fractions with names like "common denominator" and "least common multiple."

Combining two rhythms has far more and far more interesting "connections" than adding two fractions: it is directly connected to the actions of tapping out the beats; it is far more likely to be connected to a purpose that came from the child; it mediates connection with other children who hear the result and ask "how did you do that?" and it is connected to the very general and powerful idea of cyclic pattern that applies to countless situations found in nature as well as in artifacts.

An narrow minded traditional mathematics teacher might say: "so what? …. They may be learning all sorts of interesting things but it isn't real math." To this we have two replies. First it IS mathematics; the narrow minded teacher is displaying ignorance by the belief that mathematics is only that tiny sliver of mathematical knowledge that has become sanctified as "math" in the curriculum. There is much to mathematics and much more that will be more useful to children both in aiding the learning of other important things and in itself as useful knowledge later in life. Second, and perhaps more telling for the narrow-minded traditionalist, is evidence that learning this "non-math" makes the "real math" more accessible to more students. Indeed so much so that learning the two together requires less time than learning the traditional material alone.[6]

Harmonic series.

An example of a cyclic phenomenon of special importance in music is the relationship between harmonic notes. The ear tells us that an essential sound quality repeats itself in notes one octave apart and this acoustic fact is built into the names we give notes and the construction of musical instruments. But understanding why this should be so connects to concepts and areas of knowledge that are normally considered outside the range of what can be learned, or indeed of what there is any point in learning, at primary levels of schooling. We would agree completely that it would make no sense to try to insert into the traditional school a required understanding of the mathematics, physics and physiology of harmonics. But the situation is radically different in the new school we are designing.

We are not sure yet how to treat this topic if at all. We cite it here as an example of the kind of research questions that we would be exploring in a preparatory period. However we do have experience that leads us to believe that in the context of the technological infrastructure and the intellectual culture of the New this topic could be developed into forms that would combine great appeal to children with deepened understanding both of music itself and of mathematics and science. We give here a `few examples of the kinds of consideration that lead us to this belief.

1 *Design and construction of musical instruments.* We do have experience of many young people working on the construction of kinds of instruments ranging from classical guitars made of wood to entirely original instruments using digitally generated sounds. The extent of interplay between the work of construction and conceptual understanding is different in different cases but even when it plays a minor role its presence colors the children's sense of what theoretical ideas are all about. And, incidentally, a student who has devoted serious effort to building an instrument invariably wants to play it so that building instruments motivates learning music in a very classical sense.

*2* *Understanding the differences in sound quality of instruments.* The kinds of experiences with technology that these students will have had by their second or third year in the school will make studying why each kind of instrument sounds as it does concrete, accessible

[6] This as an example of the "Harel principle" that learning more can be easier than learning less. There is a good discussion of it and the report of excellent empirical study in Idit harel's book *Children Designers*.

and personally intriguing.  Clearly this kind of investigation would feed into the construction of an instrument. But even without that it leads to fascinating investigations.

3 *Study of perception.* We have experience in work where familiarity with digital tools allows children to explore areas normally studied only in advanced courses on perception. Our experience is mostly in visual perception where we found that children at fourth and fifth grade levels took great delight in inventing visual illusions and vying with one another to demonstrate the greatest effects – which required measuring the effects and this in turn led to immersion in mathematics issues. We are sure intuitively that something similar could be done in auditory perception.

## CONTENT Part 2.
## EMPHASIS ON WRITING + EXPRESSION

The kinds of learning that are usually put under the heading of “writing” or “language arts” or “English” (in the USA) or “Spanish” (in Venezuela) are a very mixed assortment. Some of them are very specifically about the particular language (e.g. spelling rules) while some of them are not even specific to language (e.g. the skills and attitudes that go into editing are much the same in film and music.)

What is special about how writing will be treated in the Mschool is correspondingly various. We discuss this under the following headings:

1. Treatments that are shared by many other existing schools and are widely discussed in literature will get only passing mention here. These include:
    a. General benefits that come from the fact that Mschool is well equipped with computers.
    b. General benefits that come from the school being “interest-based”. We share the view known sometimes as “whole language” that learning language will be enhanced by encouraging students to write about topics that are personally interesting to them and especially when the writing serves a purpose as part of a bigger project. We do assume that all students will have a greater than usual personal interest in their work.
2. Treatments that are less common include:
    a. Writing is thoroughly integrated with other forms of composition (music of course + film + drama + dance etc)
    b. Meta-study of writing, as of everything else that is done in Mschool is unusually advanced

Our remarks ascribing some of the classical difficulties in learning mathematics to its isolation are area special case of the more general thesis, which we summarize as:

1. A major source of difficulty in all school learning is the isolation of subjects:
    a. They are isolated from one another
        i. By being treated separately
        ii. By the absence of an integrative stance
    b. They are isolated from experience
        i. They are not used in the world
        ii. They are dissociated from the
2. Major contributing factor to the isolation are related to the pre-digital technology
    a. As a direct effect: traditional media impede integration
    b. As a QWERTY effect: isolation is cast in cultural, institutional and epistemological concrete
3. New technologies can be used in different ways:
    a. The “School computer culture” tends to reinforce the isolation
    b. Deliberate effort and hard work is needed to use the technology to break down the barriers
4. The Arts provide an excellent (perhaps optimal) context for an integrative view

We have already noted in our discussion of mathematics some of the negative effects of its isolation in school usage from “language.” This is deleterious on both sides: access to mathematics is made more difficult by not recognizing this function (or reducing it to a secondary status) and not the full study of language is blocked by giving it a too narrow definition. In this section we deal with further deleterious effects of separating language from other areas of study.

We begin with a brief presentation of some cases where difficulties with language are overcome by talking a less isolationist view.

1. X is a fifth grade boy in a Boston school serving an economically and socially underprivileged community. X is a remarkably good storyteller. He can hold an audience captivated by accounts of real or by made up events or by recasting stories from books. He makes masterly use of timing and intonation to manipulate tension, surprise and other audience reactions. But when asked to write he produces dull and plodding stuff. The obvious difference was that he had not learned to how to use the static medium for dynamic effects. Partly because he lacked the skills, partly because he felt "alienated" as a writer … writing was not syntonic.

   X was in a project that involved an hour a day of computer usage. Using the computer as a writing instrument produced no significant change in the quality of his writing. But when he learned how to use the computer to tell a story in the form of screen animations he produced work that was closer to his oral capability. Now, the program that he used for this (a version of Logo) allowed him to combine text with his graphics. At first he did this sparingly, using the text to label scenes rather than as a medium of story telling. But little by little he began to introduce more text in order to tell more complex stories. Eventually there was much more text than animation. But the text was much better: the obvious interpretation was that he was thinking in dynamic terms even as he wrote. As he did so he came to enjoy writing … it became syntonic.

   At the time these observations were made we did not have a smooth enough way to allow X to use music along with the animations. It is safe to assume that he would have done even better.

2. The story of X reminds one that when we talk about "writing" we include much that is not specific to using an alphabetic representation. Issues of flow are one example. Another is the set of skills and attitudes that go into "editing." Tara Shankar, my doctoral student at the Media Lab, is engaged in research on developing these skills by being able to manipulate speech (oral language) in the way that one manipulates written language with a word processor.

3. These two cases show technology making possible manipulation in the process of developing expressive compositions (written language, spoken language, animations, music etc) and improving one's ability to do so. The converse to this synthesis of composition is the analysis of compositions made by others. For example an interesting line of discussion to develop analytic skills is about the role of music in a fictional movie. This can be done with very simple old-fashioned technology – perhaps simply by turning off the sound – in a group of sophisticated college-level students. The possibility of *replacing* the music makes possible an experimental approach that allows for a far more concrete level of discussion.

# <u>CONTENT Part 3</u>

## <u>EMPHASIS ON MUSIC+COMPOSITION</u>

Everybody loves music, and there seems to be more and more of it in the world every day, surrounding us everywhere we go: playing in elevators, on car radios, on MP3 players, to hear while we eat, talk, study, dance, travel – sometimes even while we stroll outside. Surely having so much music around us is a good thing, and sometimes it is. But sometimes there is just too much of it to listen to, or at least to listen to carefully. And it seems to me that something is wrong with the fact that although there is more music than ever in the air, less of us actually *play* music or *sing* music, let alone *create* one's *own* music. We can get more out of music and more fully appreciate its wonders and powers if we absorb it, touch it, and shape it ourselves. This is especially true of children, since they are so well-suited to music-making (with their boundless energy, emotional freedom, and creative imagination), but also so often shut out by its many difficulties. Instruments are hard to play and take years to learn. Music notation is hard to read. Musical "language" is a specialized one, with its complex rules of harmony and counterpoint, rhythm, structure and form. But what if we could unlock the expressive mysteries of music before learning all the technical prerequisites, if we could fall in love with the joys of music first, and demand to deepen our knowledge once we are "hooked"?

The MIT Media Lab's **Toy Symphony** project has been an attempt to provide such an alternative entry for children into music. A series of special instruments called *Music Toys* were designed, and require no special skill but which do reward curiosity, imagination, and feeling. The technical magic of these new "hyper"-instruments eliminates years of practice, and automatically provides much of the specialized knowledge needed to pick the right note or chord, or to synchronize and jam with others. With these Music Toys, touch, and gesture, whistle, and hum can open up worlds of possibility. With continued exploration and discipline, there is no limit to how far one can develop.

For how <u>do</u> children learn music? The short answer is that they learn music by doing music - by interacting with musical material in meaningful ways as composers, performers and listeners. The challenge for music educators is to present children with appropriate objects, activities and situations to stimulate their natural creativity and enable them to grow as musicians. Toy Symphony meets this challenge in novel ways. *Beatbugs* enable children to explore aspects of rhythm, percussion and group performance, while *Shapers* provide both the opportunity to control both pitched and unpitched sounds by expressive gesture and the unique experience of making music along with the orchestra. *Hyperscore*, the specially designed graphical composition software, gives children the means to create large-scale musical structures in a direct and intuitive way and to immediately hear the results of their work. All the toys are engaging, easy to use and allow for maximum musical expression without many of the technical and educational difficulties associated with traditional music learning experiences. Projects like Toy Symphony ultimately place children at the heart of the music-making experience. They accommodate multiple musical activities, age groups, learning styles and cultural backgrounds within one overarching framework, which will stimulate the children's musical development and be an important milestone in their musical lives. They will not only lay the groundwork for the continued musical development of the children who participate, but hopefully yield new insights into the learning process and the role that technology can play in bringing music and children together. Now is the time to push the Toy Symphony model further.

## SUPPORT FROM NEUROLOGICAL RESEARCH

At root, the brain is a temporal correlation machine for anticipatory prediction (of consequences of action in terms of reward), and music may be the most fundamental human activity to make creative use of these very basic and ancient mechanisms. Recent research shows that music affects human behavior, and that active involvement in music-making—facilitated by new interface and interaction technologies, and supported by new classification schemes for mapping music to brain function—can exert a powerful influence on learning effectiveness and motivation. It is increasingly known from clinical case studies that music can affect—in very specific ways—human neurological, psychological, and physical functioning in areas such as processing language, expressing emotion, memory, and physiological and motor responses (Tomaino, 2002). And specific musical activity has been shown to have the potential to provide a valuable multi-sensory environment for a variety of learning disabilities, such as dyslexia (Overy, 2003).

In addition, we seek to make use of ways that the brain recognizes patterns in the environment, since we believe that listening to music is, in essence, an exercise in pattern recognition. Musical and sonic sequences comprise repeated tonal patterns that can vary across repetitions. Somehow, our brain is able to spot the underlying pattern, despite its variability, and can thereby discern the organizing structure of the musical sequence. Without the perception of such structure, a sequence is likely to be relegated to the status of 'noise'. In other words, our brains are wired for music in the broadest sense, constantly seeking out rhythms in sensory inputs, be they on the order of seconds or days and years. The question of *how* the brain learns to detect repeated patterns is one of the great unsolved mysteries of neuroscience. The answer would have implications for many fundamental issues ranging from music appreciation to learning to navigation and survival in the real world.

One eventual, and very ambitious, goal of this research is to develop a comprehensive understanding of how the brain discovers regularities in the world – a challenge that is justly considered a 'holy grail' problem in neuroscience. Music may provide a beautiful way of approaching this grand challenge. Studies have shown that motivation in particular, the lack of which is a core condition of many learning problems, can be enhanced by changes in background stimulus (Healy and Picard, 1999), and that music is a particularly effective stimulus. The brain integrates sensory information in ways that exceed the physical content of stimuli; this is the essence of cognition, as opposed to sensation, and is exemplified by the identification and processing of complex sensory stimuli such as music. While every sensory system engages the brain in this way, the most spectacular examples are in audition and vision. Discovering the principles by which the brain processes complex stimuli is a central goal in neuroscience. Using new knowledge uncovered in our own research to begin to define which kinds of music influences people in what specific ways, and studying how specific activities which we develop can enhance general learning, is our fundamental goal. We will do this by creating contexts through which the subject can participate actively in a musical experience, positioned in between passive listening and sustained musical study. It has recently been shown that passive listening does not induce significant changes in behavior or brain function, whereas sustained musical training has several limitations, including availability of subject's time and the tendency to emphasize physical over mental activities (Pascual-Leone, 2003). However, engagement in music and response to musical stimuli can cause significant changes in both behavior and brain activity (Schellenberg, 2003). We propose to use both affective measurement techniques and immersive musical environments designed for non-expert subjects in order to create precisely such "Active Listening" experiences which we believe are crucial for both the research and teaching aspects of the present study.

## CONCLUSION

Music is one of the most enjoyable human activities, and also one of the most mysterious. The music industry is enormous worldwide and growing, people of all ages spend countless hours listening to music, and music seems to bind to our memories in a uniquely complex way (such that Alzheimer's patients often remember – and respond to – favorite music when they have lost recall of all else). Indeed music is one of the most powerful ways of identifying ourselves as individuals and as members of a group. Because of music's indelible place at the center of our lives, it comes as a shock to realize that scientists do not have good theories about why music evolved, about why all societies have music when there is not an obvious evolutionary need, about why music moves us so deeply, and about what we are actually "doing" when we listen to or make music. But recently, this has all begun to change. Music has become a hot topic of exploration for educators, psychologists, ethnographers, and neuroscientists. In fact many believe that music is the ultimate human mystery, and that by understanding it better we can harness its forces in innovative ways to help people learn many non-musical things as well as to develop imaginative, communicative and creative skills. At the MIT Media Lab, we have extensive experience in exploring and enhancing music's unique potential, as well as having a very significant tradition of developing theories, tools and techniques for child development and lifelong learning. We believe that it is time to bring these two traditions together, putting music at the core of a new learning philosophy. Our specific proposal has several core components:

1. Implementation of a small number of model schools in which the musical arts are the carrier for all learning.
2. Development of learning materials and points of view that will allow any school to make a rapid or cautious transition to the methods used in the model schools.
3. Special attention to the evolution of rural, pre-urban and pre-industrial society, and the implementation of activities particularly suited to such societies and to ease their communication with urban cultures.
4. Extending the on-going research theme we call "Music, Movement, and Mind" to connect more directly with developmental issues.
5. The design and launching of a centralized, public facility (perhaps at a performing arts center such as PAC Miami) that would serve as a high-visibility forum for people to come together to share the joys of learning through music.

Building on our projects such as the Brain Opera, Toy Symphony, LEGO Mindstorms, and the Computer Clubhouse network, we will develop a coherent series of musical activities specially designed to stimulate the following kinds of learning:

a. mathematical structure of space and time
b. physics through use of sensors, materials, measurements, interactions
c. computer programming for implementing effective performance mappings
d. motor/vision coordination for the cerebellum through mastering notation
e. detection and expression of emotions, both isolated or in continuity
f. group cooperation for coordinating music actions and intentions
g. narrative and communication through composing and analyzing
h. social/historical explorations through attention to local cultural context
i. increased concentration and discernment through "deep listening"
j. development of fine motor skills as well as exuberant gesture

We believe that building on music's combination of serious fun, integrated mental stimulation, individual creativity, and group cooperation, will allow us to invent an unprecedented set of activities and environments that will infuse young people with the enthusiasm to learn, and allow them to excel and achieve beyond our wildest dreams.

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